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Interim Report 1-MDC-A-76

PRELIMINARY EVALUATION
20MM PLASTIC ROTATING BANDS

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Munitions Development and Engineering Directorate

U.S. ARMY ARMAMENT COMMAND
FRANKFORD ARSENAL
PHILADELPHIA, PENNSYLVANIA 19137

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PRELIMINARY EVALUATION
20MM PLASTIC ROTATING BANDS

AUTOMATIC CANNON TECHNOLOGY PROGRAM
DA PROJECT NO. 1W662603AH78.01

BY

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ABSTRACT

Experimental exploratory evaluations of plastic bands applied to ammunition for the M139 gun consisted of obtaining and evaluating data provided by comparison firings between projectiles having either plastic or copper bands in two ballistic environments, the M139 and M61 gun barrels (Mann) over the temperature range -65°F, +70°F, and +160°F. In all, 120 projectiles were fired, 60 in each environment and 10 of each band material at each conditioning temperature. In addition, photographic observation of representative in-flight projectile firings provided visible evidence of band integrity, projectile stability, and band deformation.

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INTRODUCTION

Plastic Rotating Bands have been developed and standardized for use by the U.S. Army on low performance fin stabilized projectiles. None have yet been standardized for high performance 20mm Automatic Cannon Ammunition such as the M50 Series. Current experimental investigations by the U.S. Air Force show promise to the extent of structural integrity of the band material and projectile bandseat geometry interface in M50 20mm projectiles. These encouraging results prompted an evaluation by the U.S. Army of the same design approach applied to 20mm ammunition for the M139 Hispano Suiza Gun. The basic differences between the performance levels as they affect band performance are:

a) The M139 gun utilizes a constant twist rifled barrel as opposed to the gain twist of the barrels for M50 ammunition (M61 Gun) and a heavier and longer projectile than standard M50 ammunition.

b) The bandseat of the M212A1 projectile (the TPT projectile for the M139 system) required modification to accomodate induction bonding of the band material, unmodified Nylon 12, to the projectile bandseat. (See Figure 1, Rev A SKMDC-A-3-75-001 and Figure 2, Rev A, SKMDC-A-3-75-002, for details of the designs of the M212A1 and M50 type projectiles respectively).

These experimental exploratory evaluations of plastic bands applied to ammunition for the M139 gun consisted of obtaining and evaluating data provided by comparison firings between projectiles having either plastic or copper bands in two ballistic environments, the M139 and M61 gun barrels (Mann) over the temperature range -65°F, +70°F, and +160°F. In all, 120 projectiles were fired, 60 in each environment and 10 of each band material at each conditioning temperature. In addition, photographic observation of representative in-flight projectile firings provided visible evidence of band integrity, projectile stability, and band deformation.

Evaluation data consisted of pressure and muzzle velocity measurements of all firings. Copper band projectiles provided a reference base for plastic band performance at the temperature extremes. The M50 projectile firings provided a reference base for plastic band performance in two ballistic environments, the M139 and M61 gun barrels.

All of the firings took place indoors. Velocity was calculated from time data derived from two lumeline screens spaced 50 feet apart with the first screen located 28 feet from the gun muzzle. Inflight projectile photographs were taken 35 feet from the muzzle. Cartridges were conditioned for two hours at the required temperature then fired within 1 to 1½ minutes. The gun remained at ambient temperature.

Table I contains a descriptive summary of the test hardware. The base projectile for the M139 gun barrel tests was the M212A1 TPT and for the 20mm or M50 Series ammunition, the M55A3 TP.

TABLE I

DESCRIPTION OF MATERIAL

ITEM	M50 SERIES AMMUNITION	M139 GUN AMMUNITION
Cartridge Case	M103 Brass (1)	HS Steel (1)
Primer	M36A1E1	M115 (2)
Projectile	M55A3 (3)	M212A1 (3)
Propellant Type	WG 870	CR 8325.3
Propellant Charge	590 grs	835 grs
Bullet Pull	1000 lbs	1800 lbs
Mann Barrel	#150 (4)	#163HS820 (5)

Notes:

1. Cases were drilled for recording pressure with copper crusher gages.
2. Percussion primer containing 3¼ grs. of FA 959 mix.
3. Projectiles were crimped in cases and had either standard copper bands or glass filled Nylon 12 bands.
4. Gain twist.
5. Constant twist.

Plastic rotating bands offer potential for increasing barrel life-up to two to two and one half times for equivalent ballistic systems and increasing muzzle velocity and muzzle velocity uniformity. State of the art developments project increasing barrel life by a factor of three and one half, lower costs, utilization of non-strategic, materials, and decreased drag. Derived improvements on one hand point (for equivalent ballistic systems)to lower pressures and/or decreased propellant charges. On the other hand pressures could be maintained and propellant charges increased with a derived increase in muzzle velocity.

An important consideration in utilization of plastic bands on high rate of reusage (high volume production) ammunition is cost. It has yet to be demonstrated that for the projected life of fielded systems or systems in development that cost controls exists which will provide a high degree of probability that unit cost for plastic banded projectiles will be equal to or less than copper banded projectiles.

RESULTS

Tables II through IV contain a tabulation of the test data. Table II contains a summary tabulation of the velocity and pressure data. High, low, spread, and average values are given for both plastic and copper banded projectiles.

Table III contains the detailed data for the M139 gun ammunition (M212A1 type) tests. Table IV contains the detailed data for the M50 Series ammunition firings together with data on the plastic band diameter dimension at -65°F and 160°F.

The spread (range of variation) of the data recorded for the M139 gun ammunition appears to be greater than that for the M50 Series ammunition This is explained by noting that the basic design was that used for the M50 Series. This design had not gone through an improvement cycle for the M139 gun ammunition.

TABLE II

SUMMARY OF TEST DATA

	20MM M139 GUN AMMUNITION				20MM M50 SERIES			
	CU(STD)		PLASTIC		CU(STD)		PLASTIC	
TEMP	M.V.	P.P.(cu)	M.V.	P.P.(cu)	M.V.	P.P.(cu)	M.V.	P.P.(cu)
+70°F	3561	53,300	3521	48,500	3345	41,500	3323	42,200
EXTR.	86F/S	10,600psi	160F/S	14,700	59F/S	6,100	55F/S	6,500
High	3619	59,700	3589	55,500	3369	43,900	3355	46,200
Low	3533	49,100	3429	40,800	3310	37,800	3300	39,700
-65°F	3533	54,600	3558	57,800	3230	42,500	3189	40,100
EXTR.	55F/S	7,900psi	172F/S	21,200	103F/S	6,000	106F/S	12,000
High	3562	59,700	3643	68,600	3268	44,500	3241	45,900
Low	3507	51,800	3471	47,400	3165	38,500	3135	33,900
+160°F	3584	49,900	3561	46,720	3446	47,700	3392	47,000
EXTR.	40F/S	4,400psi	70F/S	4,000	30F/S	7,700	45F/S	4,600
High	3604	52,900	3601	48,500	3465	50,400	3413	49,100
Low	3564	48,500	3531	44,500	3435	42,700	3368	44,500

TABLE III

M139 GUN AMMUNITION TEST DATA

ROUND	TEMP.	PROJ. TYPE	M.V.	P.P. (cu)	REMARKS
946	+70°F	Copper Rotating Band (Std.)	3545	49,600	No unburnt pwd.
947			3540	49,100	
948			3559	53,900	
949			3574	59,200	
950			3533-	52,300	
951			3563	55,000	
952			3560	53,400	
953			3619+	59,700	
954			3577	50,200	
955			3552	50,200	
		AVG	3561	53,300	
		EXTREME	86 F/S	10,600 psi	
956	+70°F	Plastic Rotating Band	3429-	40,800-	No unburnt pwd.
957			3560	55,500	
958			3515	47,400	
959			3497	51,100	
960			3487	44,200	
961			3468	42,200	
962			3553	49,100	
963			3579	52,600	
964			3530	49,600	
965			3589+	52,500	
		AVG	3521	48,500	
		EXTREME	160 F/S	14,700 psi	
966	-65°F	Copper Rotating Band (Std.)	3545	51,800	(See Temperature Note)
967			3540	55,500	
968			3545	56,600	
969			3511	51,800	
970			3507	54,500	
971			3562	59,700	
972			3529	54,500	
973			3526	52,900	
974			3543	53,900	
975			3525	55,000	
		AVG	3533	54,600	
		EXTREME	55 F/S	7,900 psi	

TABLE III (CONT)

M139 GUN AMMUNITION TEST DATA

ROUND	TEMP.	PROJ. TYPE	M.V.	P.P. (cu)	REMARKS
976	-65°F	Plastic Rotating	3643	68,600	(See Temperature
977		Band	3482	48,000	Note)
978			3592	59,200	
979			3558	56,100	
980			3587	60,800	
981			3496	53,900	
982			3585	62,800	
983			3471	47,400	
984			3575	58,700	
985			3594	60,800	
		AVG	3558	57,800	
		EXTREME	172 F/S	21,200 psi	
986	+160°F	Copper Rotating	3571	49,100	(See Temperature
987		Band (Std.)	3591	49,600	Note)
988			3591	52,900	
989			3571	48,500	
990			3604	50,700	
991			3564	49,600	
992			3575	49,800	
993			3601	49,600	
994			3584	49,600	
995			3589	49,600	
		AVG	3584	49,900	
		EXTREME	40 F/S	4,400 psi	
996	+160°F	Plastic Rotating	3549	46,300	(See Temperature
997		Band	3562	45,700	Note)
998			3553	47,800	
999			3601	48,500	
1000			3531	46,000	
1001			3540	44,500	
1002			3543	46,600	
1003			3563	46,800	
1004			3584	48,500	
1005			3580	46,500	
		AVG	3561	46,720	
		EXTREME	70 F/S	4,000 psi	

TABLE IV

M50 SERIES AMMUNITION TEST DATA

RD.	TEMP.	PROJ. TYPE	M.V.	P.P.(cu)	REMARKS
1.	+70°F	Copper Rotating Band (Std)	3339	43,300	No Unburnt Pwd.
2.			3327	41,500	
3.			3366	43,300	
4.			3361	43,300	
5.			3316	37,800-	
6.			3365	39,100	
7.			3310-	39,700	
8.			3369+	43,900+	
9.			3346	40,300	
10.			3352	42,700	
		AVG	3345	41,500	
		EXTREME	59F/S	6,100psi	
11.	+70°F	Plastic Rotating Band	3308	42,200	No Unburnt Pwd.
12.			3311	41,500	
13.			3355+	46,200+	
14.			3316	40,900	
15.			3300-	40,300	
16.			3355	45,100	
17.			3330	43,300	
18.			3302	39,700-	
19.			3345	42,700	
20.			3311	40,300	
		AVG	3323	42,200	
		EXTREME	55F/S	6,500 psi	
21.	-65°F	Copper Rotating Band (Std)	3175	38,500-	
22.			3253	43,900	
23.			3197	39,700	
24.			3225	42,700	
25.			3268+	44,500+	
26.			3267	44,200	
27.			3258	43,900	
28.			3258	44,500	
29.			3231	43,300	
30.			3165-	39,700	
		AVG	3230	42,500	
		EXTREME	103 F/S	6,000 psi	

TABLE IV (CONT)

M50 SERIES AMMUNITION TEST DATA

RD.	TEMP.	PROJ. TYPE	M.V.	P.P.(cu)	P.R.B. MEASUREMENT +70°	P.R.B. MEASUREMENT -65°
31.	-65°F	Plastic Rotating	3217	43,100	.8266	.8249
32.		Band	3230	42,700	.8257	.8244
33.			3228	45,900+	.8252	.8236
34.			3190	40,200	.8261	.8249
35.			3154	33,900-	.8263	.8250
36.			3241+	43,300	.8250	.8243
37.			3153	37,800	.8250	.8234
38.			3184	39,700	.8277	.8258
39.			3158	38,100	.8253	.8246
40.			3135-	36,100	.8257	.8245
		AVG	3189	40,100		
		EXTREME	106 F/S	12,000psi		
41.	+160°F	Copper Rotating	3440	45,500		
42.		Band (Std)	3443	49,600		
43.			3453	49,500		
44.			3435-	47,700		
45.			3444	44,400		
46.			3465+	50,400+		
47.			3445	47,400		
48.			3435	42,700-		
49.			3460	50,200		
50.			3443	49,600		
		AVG	3446	47,700		
		EXTREME	30 F/S	7,700psi		
					P.R.B. MEASUREMENT +70°	P.R.B. MEASUREMENT +160°
51.	+160°F	Plastic Rotating	3368-	46,800	.8271	.8279
52.		Band	3390	46,200	.8270	.8283
53.			3397	47,400	.8270	.8274
54.			3392	48,000	.8267	.8270
55.			3411	44,500-	.8266	.8285
56.			3388	47,400	.8230	.8270
57			3375	45,600	.8259	.8271
58.			3390	47,400	.8251	.8260
59.			3392	48,000	.8245	.8263
60.			3413+	49,100	.8270	.8277
		AVG	3392	47,000		
		EXTREME	45 F/S	4,600 psi		

In-flight photographs are reproduced in Figures 3 through 17. Figures 3 through 11 cover the M50 Series ammunition tests while Figures 12 through 17 cover the M139 gun ammunition tests. The first three figures of each set are those for copper banded projectile firings. The remainder are for plastic banded projectile firings.

CONCLUSIONS

These limited experimental tests confirm that plastic banded projectiles will remain structurally sound when fired in Mann barrels in the two selected ballistic environments.

Photographic evidence reveals trailing of the plastic band in both ballistic environments at 70°F and 160°F. Projectile stability does not appear to be degraded. In general, ballistic data satisfied existing specification.

RECOMMENDATIONS

Single shot performance data, obtained by means of Mann barrel firings, need to be augmented by both single shot and automatic data obtained by firing tests in service guns, having various degrees of barrel wear and gun temperature environments.

Accelerated aging tests of the plastic band/projectile band seat interface are required to provide a reliable estimate of storage or service life.

Additional experimental data must be acquired for constant twist barrel firings of M50 type projectiles and upper limits for structural integrity in terms of pressure and velocity.

REFERENCES

USAF Report AFATL-TR-74-106, "Plastic Band Development".

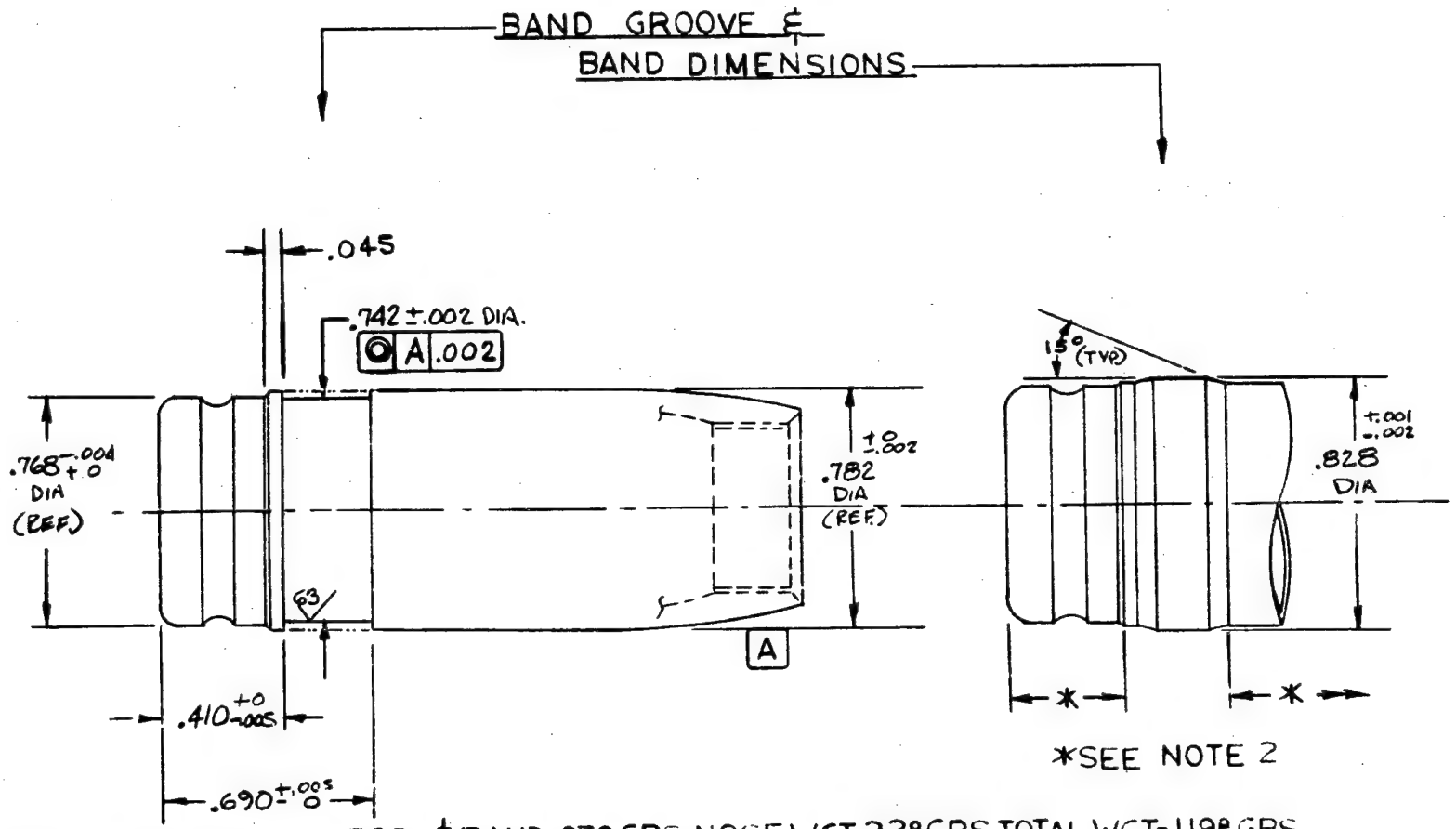


FIGURE 1

M50 Type Projectile Body (M50 Series Ammunition)

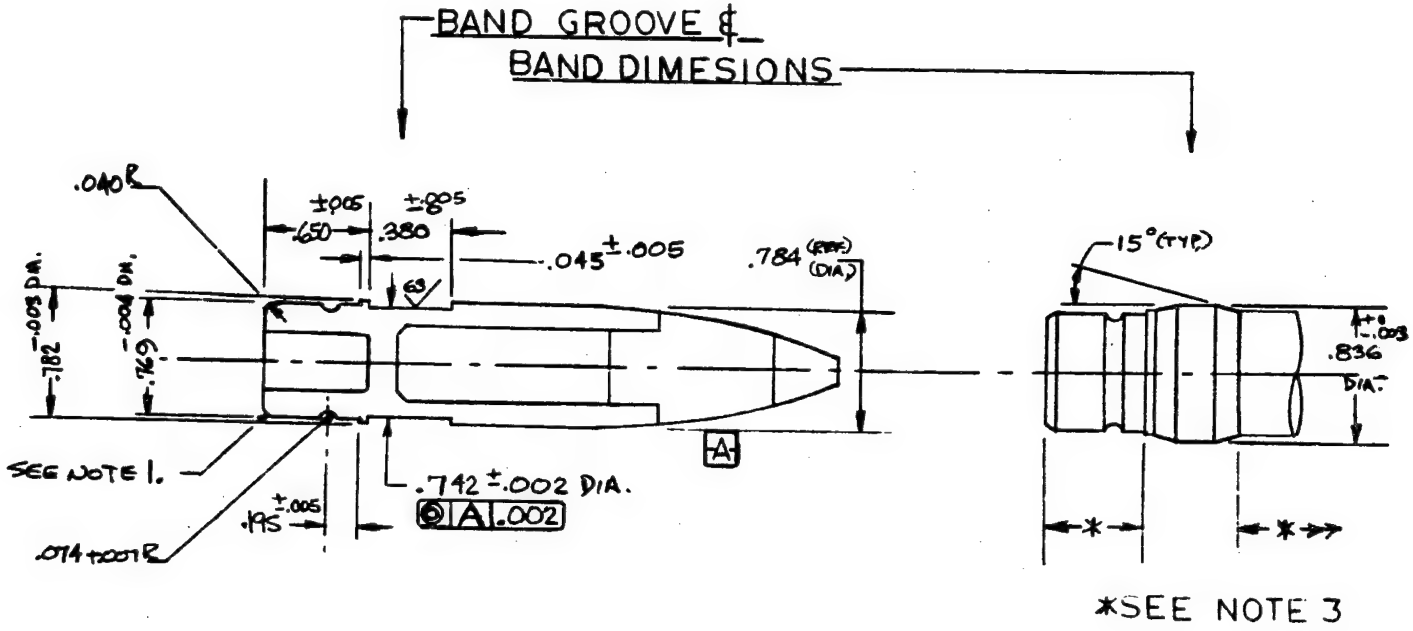


FIGURE 2

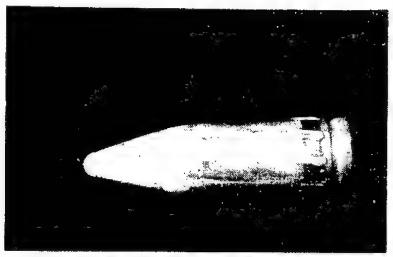
HS HEI-T Type Projectile Body (M139 Gun Ammunition)

NOTES:-1. MACHINE BACK EDGE FLAT.
2. APPROX. WGT.-BODY & BAND=1314 GRS, NOSE WGT=228 GRS, TOTAL WGT=1542 GRS.
3. AFTER BAND APPLICATION-REMOVE FLASH FROM BODY IN AREAS INDICATED.

FIGURE 3

M50 Series Ammo, Copper Band, -65°F, Photographs

RD 21



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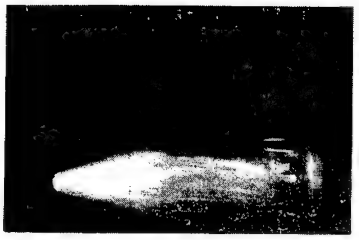

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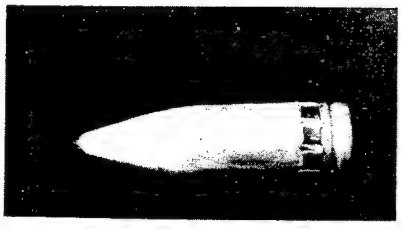
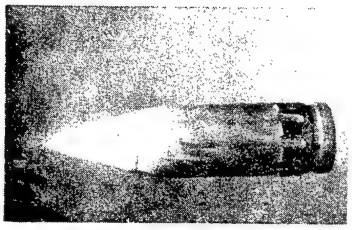


FIGURE 4

M50 Series Ammo, Copper Band, 70°F, Photographs

RD 1



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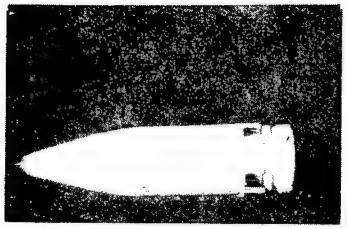

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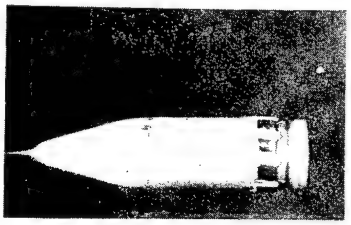

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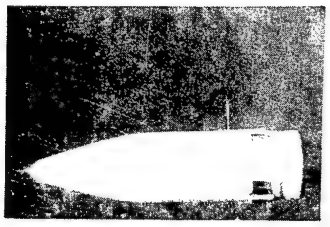
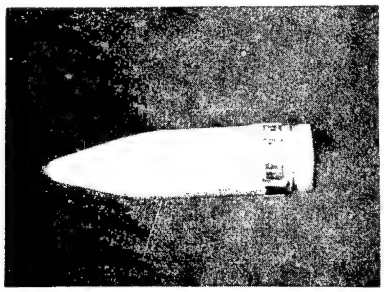


FIGURE 5

M50 Series Ammo, Copper Band, 160°F, Photographs

RD 42



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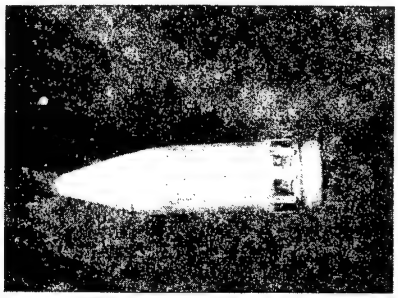

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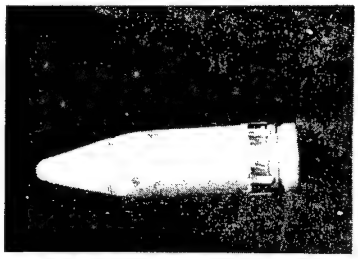

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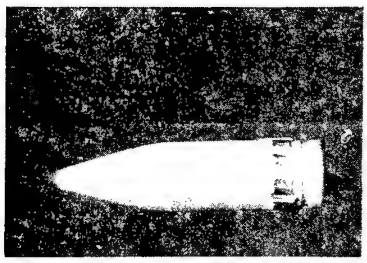
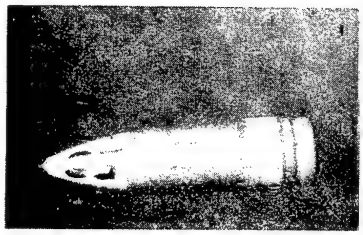


FIGURE 6

M50 Series Ammo, Plastic Band, -65°F, Photographs

RD 31



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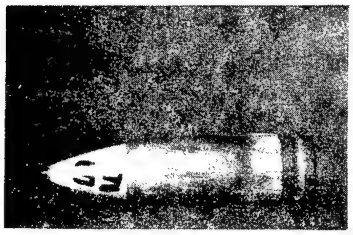

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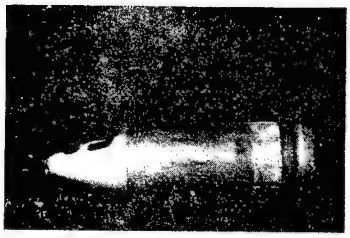

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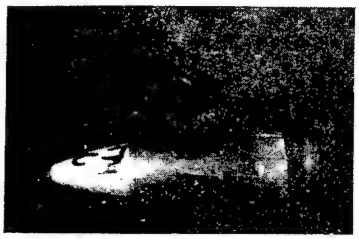

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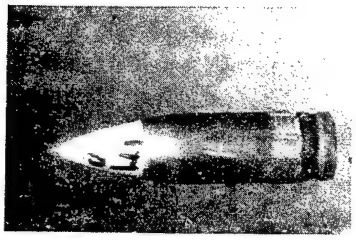

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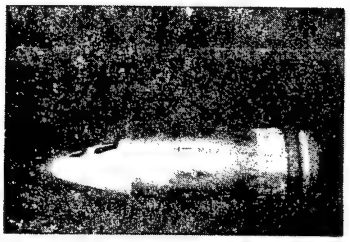
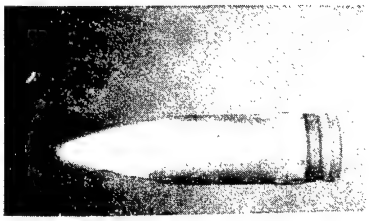


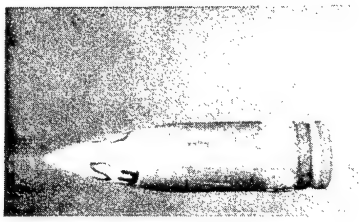
FIGURE 7

M50 Series Ammo, Plastic Band, -65°F, Photographs

RD 38



RD 39

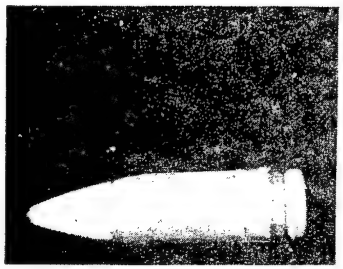


RD 40

FIGURE 8

M50 Series Ammo, Plastic Band, 70°F, Photographs

RD 11



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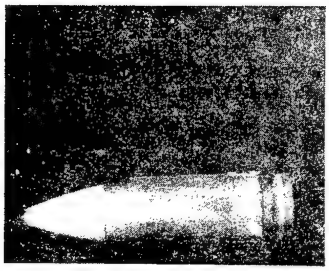

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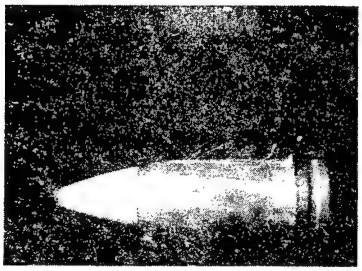

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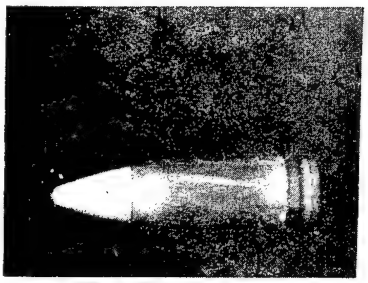

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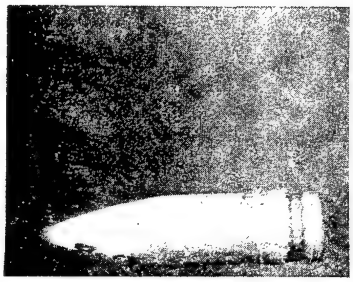

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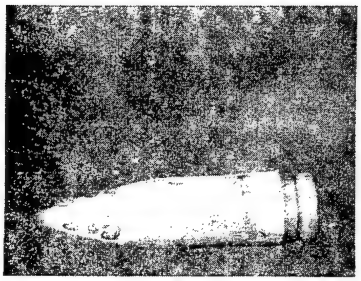
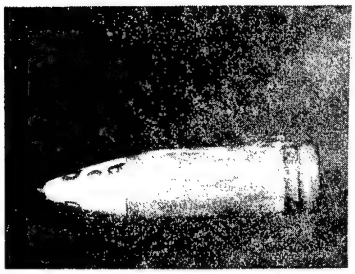


FIGURE 9

M50 Series Ammo, Plastic Band, 70°F, Photographs

RD 17



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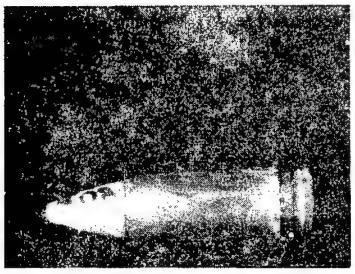

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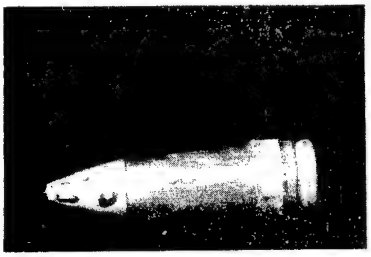

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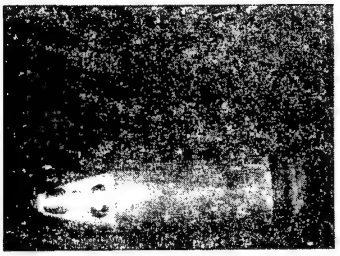
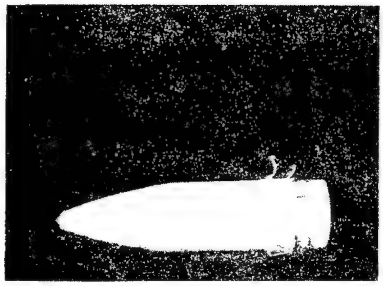


FIGURE 10

M50 Series Ammo, Plastic Band, 160°F, Photographs

RD 51



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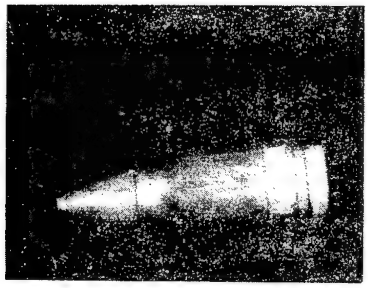

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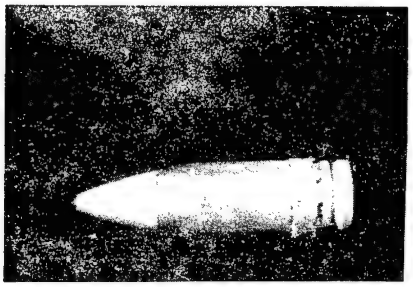

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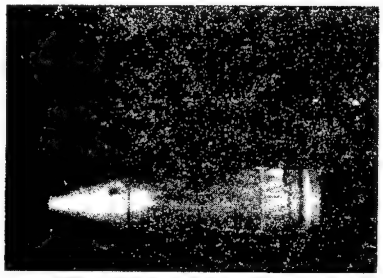


RD 55

RD 56

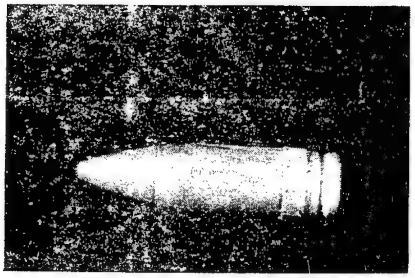
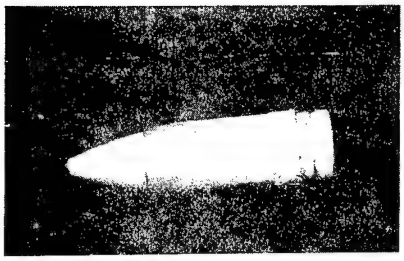


FIGURE 11

M50 Series Ammo,Plastic Band, 160°F, Photographs

RD 57



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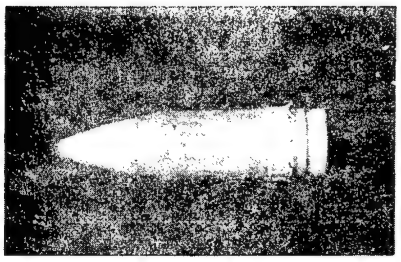

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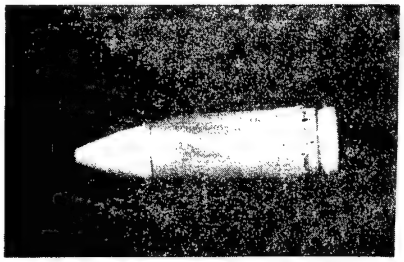

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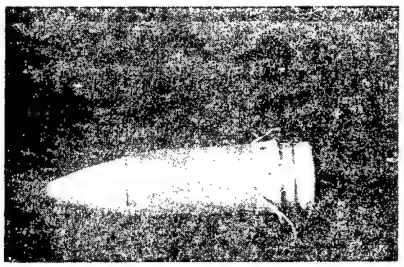
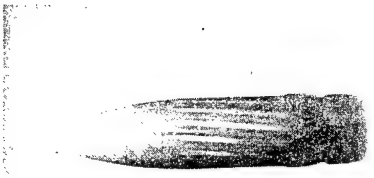


FIGURE 12

M139 Gun Ammo, Copper Band, -65°F, Photographs

RD 968

RD 970



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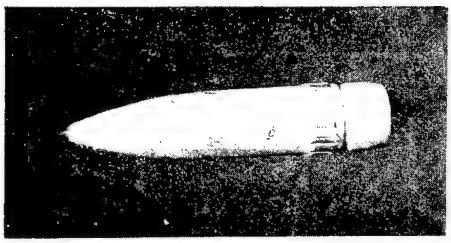

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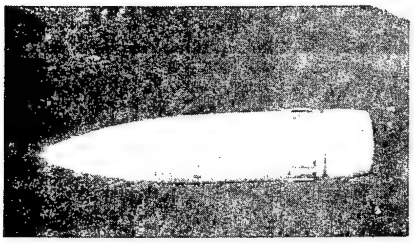


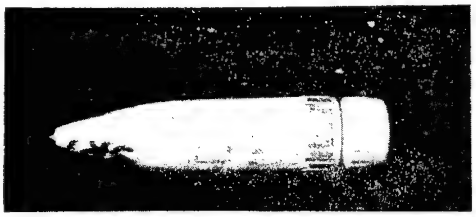
FIGURE 13

M139 Gun Ammo, Copper Band, 70°F, Photographs

RD 952

RD 953

RD 954



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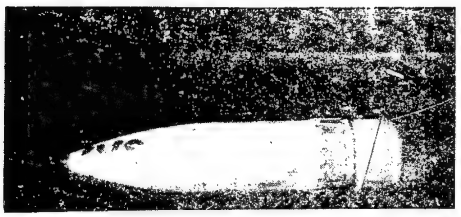
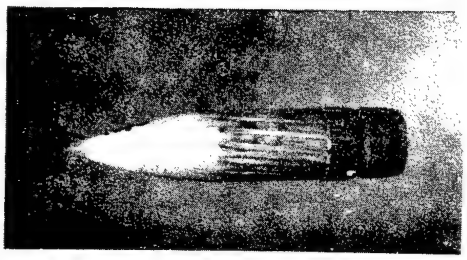


FIGURE 14

M139 Gun Ammo, Copper Band, 160°F, Photographs

RD 988



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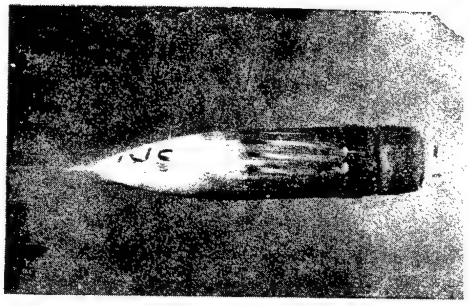

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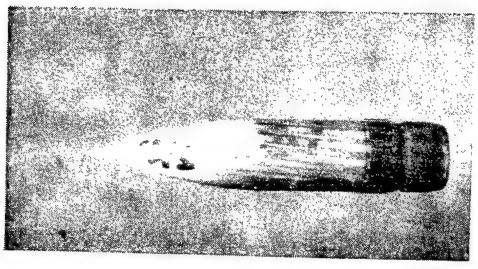
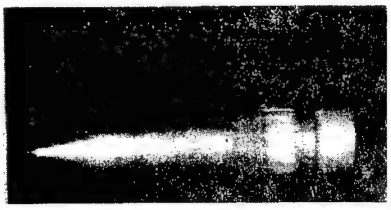


FIGURE 15

M139 Gun Ammo, Plastic Band, -65°F, Photographs

RD 976



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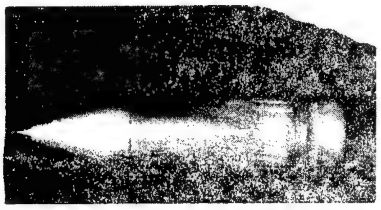
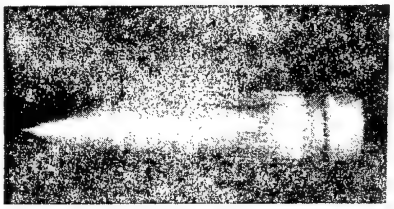
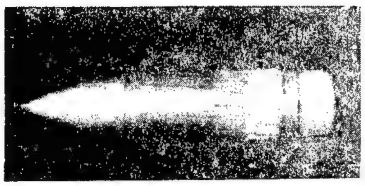


RD 978



RD 979

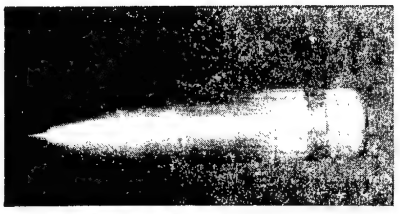
RD 980



RD 981

RD 982

RD 983



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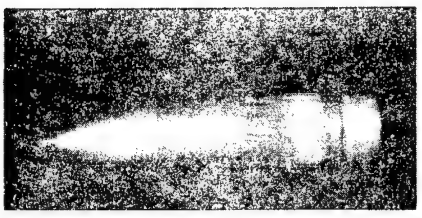

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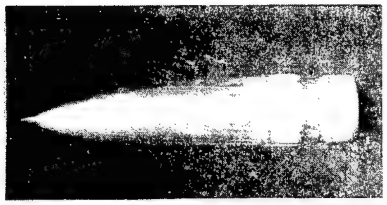
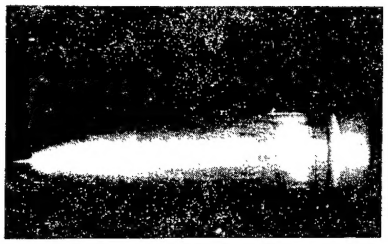


FIGURE 16

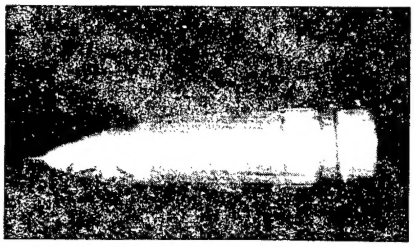
M139 Gun Ammo, Plastic Band, 70°F, Photographs

RD 956



RD 957

RD 958



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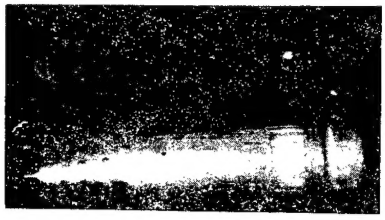

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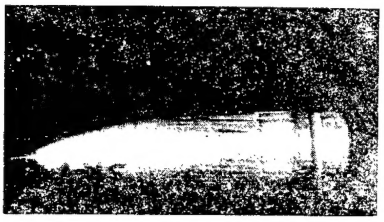

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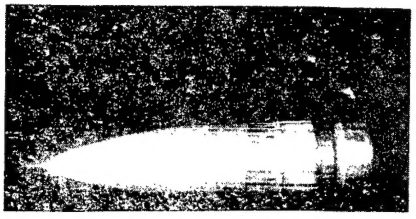

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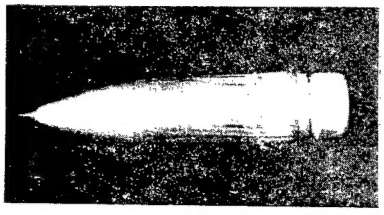

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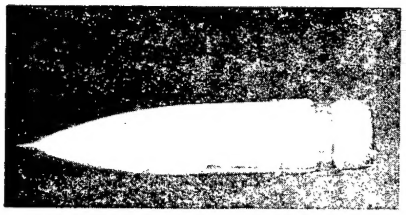

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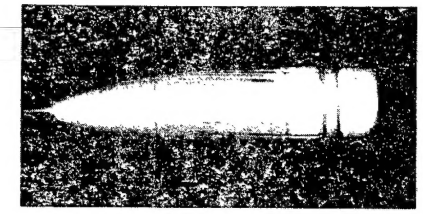

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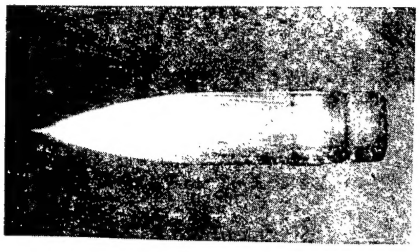
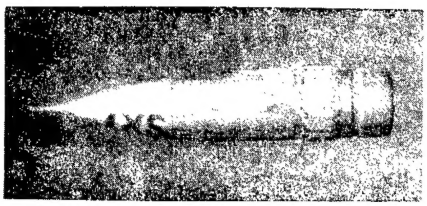


FIGURE 17

M139 Gun Ammo, Plastic Band, 160°F, Photographs

RD 997

RD 999



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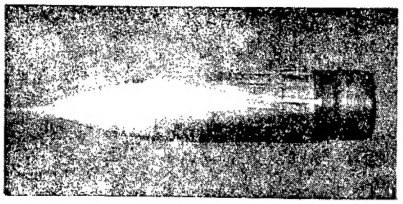
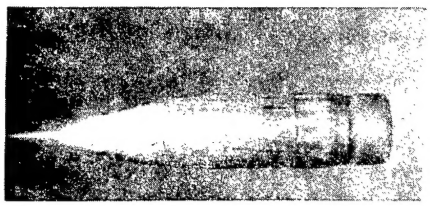


RD 1001



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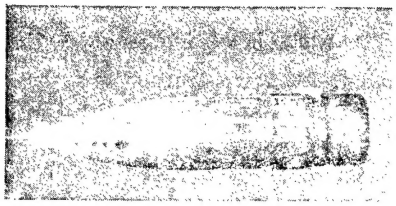

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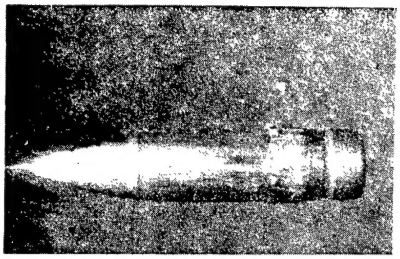

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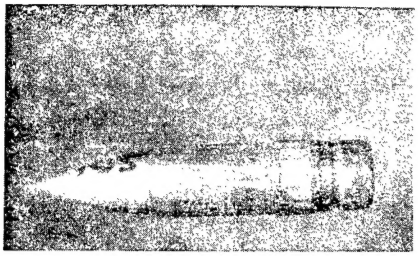

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